CHAPTER 1
PROJECT BACKGROUND

1.1 BACKGROUND STUDY

The chocolate processing industry is generally considered to be the one of the source of food processing wastewater in our countries. Although the chocolate processing industry is not commonly associated with severe environmental problems, it must continually consider its environmental impact. The chocolate processing industry handles large volumes of fat, oil and the major waste material from processing is the water. The water removed from the chocolate can contain considerable amounts of organic products and minerals. Chocolate processing wastewater treatment is clarified using the processes of coagulation and flocculation, which remove suspended solids from water by causing the suspended particles to aggregate into a slime that settles out of the water. This technique is used as a first step in treating raw water.

Coagulation used coagulant agent, which bond to the suspended particles, making them less stable in suspension, i.e., more likely to settle out. Figure 1 depicts the coagulation process in the resident tank by diagonal lines. While flocculation is the binding or physical enmeshment of these destabilized particles, and results in a slime that is heavier than water, which settles out in a clarifier or tank. (Rosemount A, 2004). The maximum permissible concentrations of these substances in the discharge of the wastewater treatment plant are defined by government standards. In addition, for the most important substance groups, purification performance expressed in percent-in other words, elimination rates relative to the amount of material fed into the wastewater.

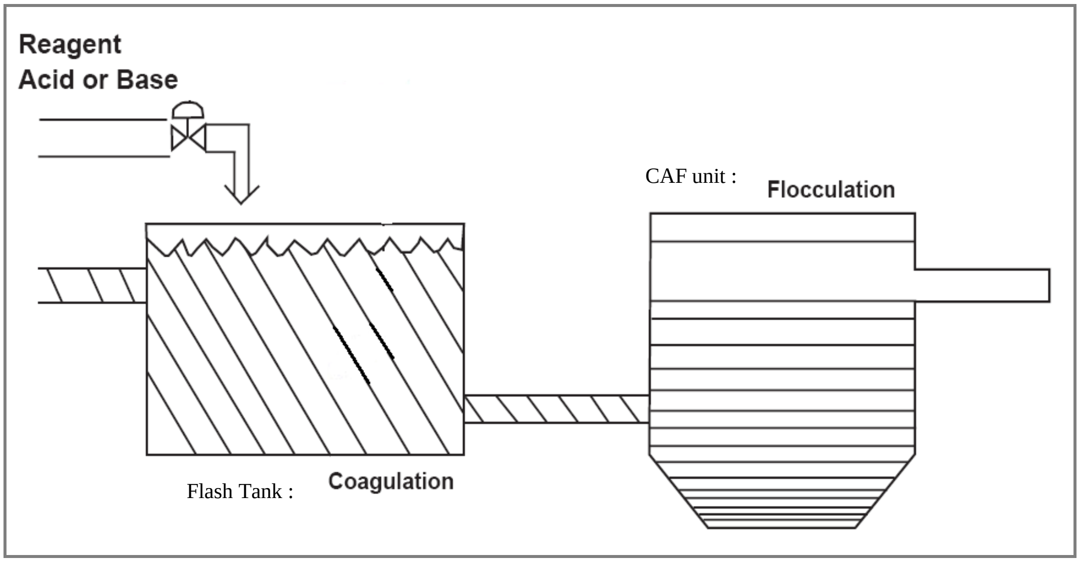

Figure 1: Coagulation and Flocculation

1.2 PROBLEM STATEMENT

Most often, in chocolate processing wastewater contains mixtures of inorganic and organic chemicals. As awareness of the importance of improved standards of wastewater treatment grows,process requirement have become more stringent (1). The suspended or colloidal solids removal from the effluent water becoming an important because the company should comply with the local regulation, refer to the appendix I. In chocolate processing wastewater, the advanced treatment of sludge removal such as chemical coagulation and flocculation may be used as pretreatment in order to enhance the biodegradability of wastewater during the biological treatments. However, there are a lot of coagulants and flocculants in the market. Differences types of effluents need different types of coagulants and flocculants. Besides, if the chemical treatmet is not functioning very well becuase unsuitable parameters, it will effect biological treatment, thus suspended or colloidal solids will discharge to the monsoon drain.

1.3 OBJECTIVES

1. To determine the parameters affecting the coagulation and flocculation processes inside the Flash tank and CAF unit.
2. To develop a treatment system that can effectively reduce the concentration of colloidal particles in the chocolate processing wastewater treatment plant.
3. To determine the suitable coagulant and flocculant for sludge removal in chemical treatment inside the Flash tank and CAF unit.

1.4 SCOPE OF STUDY

The whole project would start with the knowledge gathering and theoretical studies. Taking the sample from the potential industry would be the first step in this project, followed by finding types of coagulants and flocculants. Then, a methodology will be developed according to the step-by-step procedures from identifying, researching, and analyzing the coagulants and flocculants. Followed by the experiments which will be carried out to correlate the theoretical knowledge with practices. The experiments include the analytic coagulants and flocculants in Flash Tank and CAF unit and conducting jar test. Meanwhile, further research and development would be continuously practiced to ensure satisfactory results are achieved.

1.5 FEASIBILITY STUDY

The feasibility study of the project within the scope is to get the best way how to manage the entire task in completing the research project. For this first part of the research project, understanding of previous research done will be made. All relevant information will be gathered in being the guide in completing this study. Preparation of experiment methods of coagulant and flocculants will also be proceed depending on the availability of chemicals, equipment and workstation. The timeline of the study is as attached in appendix IV

CHAPTER 2

LITERATURE REVIEW

2.1 WASTE GENERATION

2.1.1 Raw Materials

Chocolate processing effluent contains predominantly cocoa powder, chocolate liquor, cocoa crumb and cocoa butter which have been lost from the process. The constituents present in chocolate processing effluent are chocolate fat, milk, glucose, as well as sodium, potassium, calcium and chloride.

Figure 2: Raw Materials for processing chocolate.

2.1.2 Wastewater from Associated Processes

Most of the water consumed in a chocolate processing plant is used in associated processes such as the cleaning like detergents, acidic and caustic cleaning agents and washing of floors, bottles, crates, vehicle, cleaning in place (CIP), factory equipments and tanks. CIP systems consist of three steps; a prerinse step to remove any loose raw material or product remain, a hot caustic wash to clean equipment surfaces and a cold final rinse to remove any remaining traces of caustic.

A major contributing factor to a chocolate processing plant's effluent load is the cumulative effect of minor and, on occasions, major losses of chocolate. These losses can occur, for example, when pipework is uncoupled during tank transfers or equipment is being rinsed. All of the waste generation come from the chocolate process will be sent to the wastewater treatment plant for further treatment before discharge it to the monsoon drain. The influents will be mixed up and hardly to separate because the colloidal particles are too small.

Figure 3: Wastewater Generates From Cleaning Area.

2.2 COLLOIDS

2.2.1 Characteristics of Colloids

Solids are present in water in three main forms: suspended particles, colloids and dissolved molecules. Suspended particles, such as sand, vegetable matter and silts, range in size from very large particles down to particles (A. Koohestanian, 2008) .Dissolved molecules are present as individual molecules or as ions .Colloidal particles are defined by size. Their size range is generally considered as being from 0.001 micron (10^{-6}mm) to one micron (10^{-3}mm) (S.Y.Qasim, 2000). Some particles size common are listed in table 1, along with their terminal settling velocity. From this value it is obvious that plain sedimentation will not be very efficient for smaller suspended particles.(H.S. Peavy).

Table 1 : Settling Velocities Of Various Particles

Particle diameter mm	Size typical of	Settling velocity
10	Pebble	0.73 m/s
1	Coarse Sand	0.23 m/s
0.1	Fine Sand	1×10^{-2} m/s
0.01	Silt	1×10^{-4} m/s
0.0001	Large Colloid	1×10^{-8} m/s
0.000001	Small Colloid	1×10^{-13} m/s

Gravity settling

In general, suspended particles are simply removed by conventional physical treatment like sedimentation and filtration. Dissolved molecules cannot be removed by conventional physical treatment. Thus, the removal of colloids is the main objective and the most difficult aspect in conventional water treatment. There are two types of colloids: hydrophilic colloids and hydrophobic colloids. Hydrophobic colloids, including clay and non-hydrated metal oxides, are unstable. The colloids are easily destabilized. Hydrophilic colloids like soap are stable. When these colloids are mixed with water, they form colloidal solutions that are not easily destabilized. Most suspended solids smaller than 0.1 mm found in waters carry negative electrostatic charges. Since the particles have similar negative electrical charges and electrical forces to keep the individual particles separate, the colloids stay in suspension as small particles (A. Koohestanian, 2008).

The chocolate processing wastewater is highly polluting with a high organic load, much of which is associated with finely divided colloidal or dissolved organic matter. It is also acidic and has a high fat content. However, it is non-toxic and biodegradable. A typical characteristic of chocolate processing is as shown in Table 2. The finely divided nature of the suspended solids militates against efficient solids separation and the large proportion of colloidal and dissolved solids present minimizes the effectiveness of solids separation.

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Table 2: Characteristics of Chocolate Processing Wastewater (Cadbury, Jun 2009)

Parameter	Data
Turbidity	20000 NTU
COD	8861 mg/L
SS	3095 mg/L
Oil & Grease	3095 mg/L
pH	4.5

By virtue of their particle size, the suspended solids in chocolate processing are unlikely to settle readily unaided. Aid therefore, must be provided in the form of chemical coagulation and flocculation. The strength of the aggregated particles determines their limiting size and their resistance to shear in subsequent processes. For particles in the colloidal and fine-supra colloidal size ranges (less than 1-2 microns), natural stabilizing forces (electrostatic repulsion, physical separation by absorbed water layers) predominate over the natural aggregating forces *(van der Waals)* and the natural mechanism (Brownian movement) which tends to cause particle contact. Coagulation of the fine particles involves both de-stabilization and physical processes that disperse coagulants and increase the opportunity for particle contact. Designs of chemical treatment facilities for removal of suspended solids must take into account the types and quantities of chemicals to be applied as coagulants, coagulant aids and for pH control and the associated requirements for chemical handling and feeding and for mixing and flocculation after chemical addition.

2.3 COAGULANTS

2.3.1 Definition

Chemicals that cause very fine particles to clump together into larger particles. Coagulation can be interpreted as chemical conditioning of colloids and involves the addition of chemicals that modify the physical properties of colloids to enhance their removal. Inside this process chemicals are added to water either to break down the stabilizing forces, enhances the destabilizing forces, or both (S.Y.Qasim, 2000).

2.3.2 Coagulation theory

Colloidal suspension that do not agglomerate naturally called stable. The most important factor contributing to the stability of colloidal suspensions is the excessively large surface area per unit volume of the particles makes colloids can adsorb materials such as water molecular and ions. Ions contained in the water near the colloidal will be affected by the charged surfaces. A negatively charged colloid with a possible configuration of ions around it is shown in the figure 2 below (H.S. Peavy,1985).

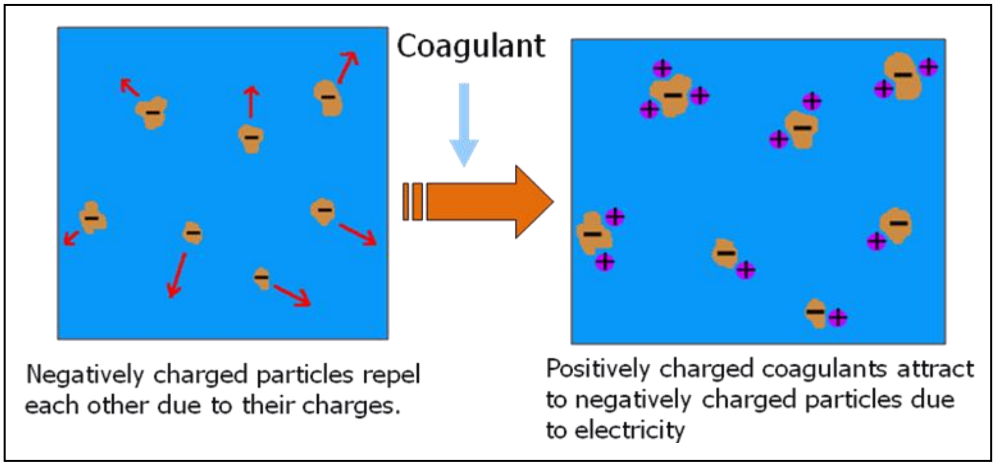


Figure 4: Coagulation Process Reaction Mechanism

The conversion of colloidal and dispersal particles into small visible floc upon addition of a simple cation. Cationic coagulants provide positive electric charges to reduce the negative charge (zeta potential) of the colloids. The magnitude of the zeta potential (Zp) is usually used to indicate colloidal particle stability. The higher the zeta potential, the greater are the repulsion forces between the colloidal particles and, therefore, the more stable is the colloidal suspension. A high Zp represents strong forces of separation (via electrostatic repulsion) and a stable system, i.e. particles tend to suspend. Low Zp indicates relatively unstable systems, i.e. particles tend to aggregate (A. Koohestanian, 2008).

As a result, the particles collide to form larger particles (flocs). Rapid mixing is required to disperse the coagulant throughout the liquid. Care must be taken not to overdose the coagulants as this can cause a complete charge reversal and restabilize the colloid complex

(Water Specialist Tech,2003). The literature review did not provide much reference on the suitable coagulants and flocculants for chocolate processing waste water (Tapas Nandy, 2003). However the common coagulants for removal organic substances used in wastewater treatment plants as shown in the table below:

Table 3: Common Inorganic Coagulants

No.	***Types of Coagulants***	***Description***
1	Aluminium Sulphate 	Commonly used coagulants for water treatment. The results of jars tests show that the optimal dose of aluminium sulphate is 50mg / L. Using an agitator turning to 300 turns per minute The pH is stabilized at 4.1. (Bachir Meghzili, 2008)
2	Ferric Chloride 	Commonly used coagulants for water treatment. The results of jars tests show that the optimal dose of Ferric Chloride is 300-350mg / L. Using an agitator turning to 300 turns per minute The pH is stabilized at 3-7.(Nik Norulaini,2001)
3	Ferric Sulfate 	Commonly used coagulants for water treatment. The results of jars tests show that the optimal dose of ferric sulfate is 150-200mg / L. Using an agitator turning to 300 turns per minute The pH is stabilized at 3-7.(Nik Norulaini,2001)

MSDS for coagulants are in the appendix II

2.4 FLOCCULANTS

2.4.1 Definition

A chemical agent that causes small particles to aggregate (flocculate). Flocculation, the agglomeration of destabilized particles into large particles, can be enhanced by the addition of high-molecular-weight, water-soluble organic polymers. These polymers increase floc size by charged site binding and by molecular bridging.

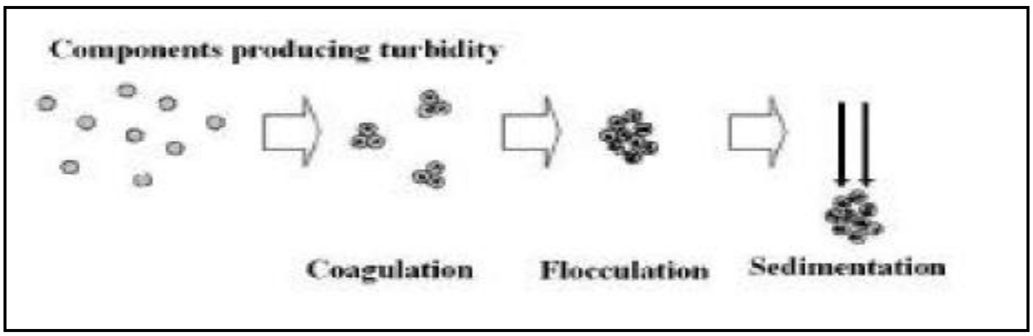


Figure 5: Coagulation, flocculation and sedimentation process

2.4.2 Flocculation Theory

An anionic flocculant will react against a positively charged suspension, adsorbing on the particles and causing destabilization either by bridging or charge neutralization (Water Specialist Tech, 2003). Therefore, coagulation involves neutralizing charged particles to destabilize suspended solids. In most clarification processes, a flocculation step then follows

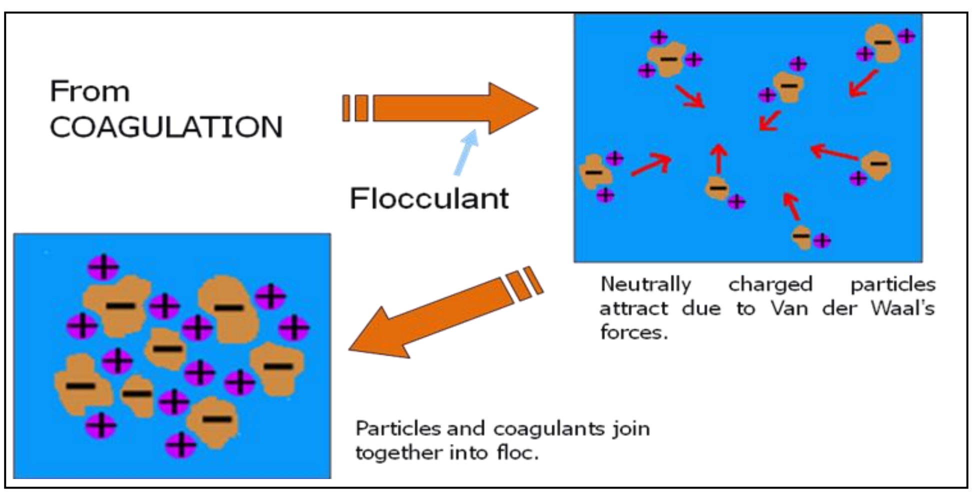


Figure 6: Flocculation Process Reaction Mechanism.

To find purified water from the effluent, we should conduct jar test to get suitable flocculants in chocolate processing wastewater. So, below are the types of flocculants used in the experiments:

Table 4:Common Inorganic Flocculants

No.	***Types of Flocculants***	***Types Uses***
1	Poly(aluminium chloride) 	Commonly used flocculants for water treatment. The results of jars tests show that the optimal dose of Poly(aluminium chloride) is 1.9 g / L. The pH is stabilized at 7.5 -8.5.(Amokrane,1997)
2	Poly(acrylamide) 	Commonly used flocculants for water treatment. The results of jars tests show that the optimal dose of Poly(acrylamide) is 0.5 g / L. The pH is stabilized at 5 -12.(Acme Chemical,2005)

The literature indicates that polymerized form of aluminium can be more effective than common salts alone in the physic-chemical treatment of wastewater. In addition, organic polymers or polyelectrolyte are also use in wastewater treatment because polymers of varying molecular weight charge density are available. The flocs produced are stronger than those formed by simple salts, and often separation can be performed by simple decantation. Also disadvantage of using salts is the amount of sludge formed often increases with an increased amount of salt, and also addition of total dissolve solid (TDS) to treated wastewater. Therefore PAC and cationic polyelectrolyte have also been selected for experimentation along with common salts of aluminum and iron (Tapas Nandy, 2003).

Besides, it indicates that flocculation water treatment is characterized by low capital and operational expenses as compared to the other methods of water treatment. A number of monographs and reviews are devoted to the problems of flocculation model and real disperse systems using polyacrylamide flocculants. In view of this information and taking into account the most significant latest data, the present review considers the basic patterns of treating natural waters and sewage with polyacrylamide (PAM) and its anionic and cationic derivatives in the presence and absence of mineral coagulants, as well as the most efficient ways of intensive water treatment (V.F.Kurenkov, 2002). MSDS for flocculants are in the appendix III

2.5 FLASH TANK

The influent from chocolate processing industry will be sent to equalization tank before pumped to the Flash tank via level sensor. The Coagulant will be dosed in from it storage tank and coagulation process happens inside this tank. The coagulant will be mixed with the influent to form pin flocs. After the process inside the flash tank, the influent with the pin flocs will be sent to the CAF unit for further treatment.

Figure 7: Flash Tank

2.6 CAF (CAVITATIONAL AERATION FLOATATION) UNIT

After chemical reaction inside the flash tank which form pin floc, the influent will be sent to CAF unit. Here, where the sludge will be separated from solution leaving water for the next treatment. Inside this tank, there two chemical dosed into the tank; caustic soda and flocculant.

Figure 8: CAF unit

The caustic soda is used for neutralization process which will neutralize the ongoing treated water to the pH range of 6.5 – 7.5. This neutralization process is important to give better flocculation process. The flocculation process is the action of polymer to form bridges between the flocs and bind it to a larger particle. The hydrocal mixer will create air bubble that will get attached to the floc and bring it to the surface of the CAF unit. Here, the floating floc will be scrapped by the scrapper.

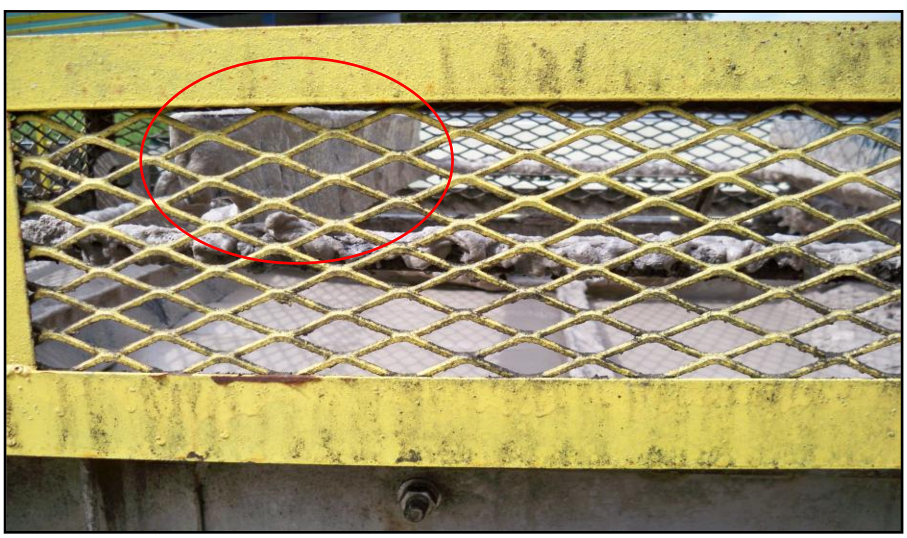


Figure 9: Floating flocs will be scrapped by scrapper.

2.7 JAR TEST

2.7.1 Definition

Jar test is a pilot-scale test of the treatment chemicals used in a particular water plant. It simulates a full scale water treatment process, providing system operators a reasonable idea of the way a treatment chemical will behave and operate with a particular type of raw water. Because it mimics full-scale operation, system operators can use jar testing to help determine which treatment chemical will work best with their system's raw water. (Zane Satterfield, 2005).

2.7.2 Parameters

The conventional jar test involved setting up a series of samples of wastewater on a special multiple paddle stirrers and dosing the samples with a range of various coagulants and flocculants in

- Different types of chemical
- Different types chemical dosage
- pH
- Rapid mixing

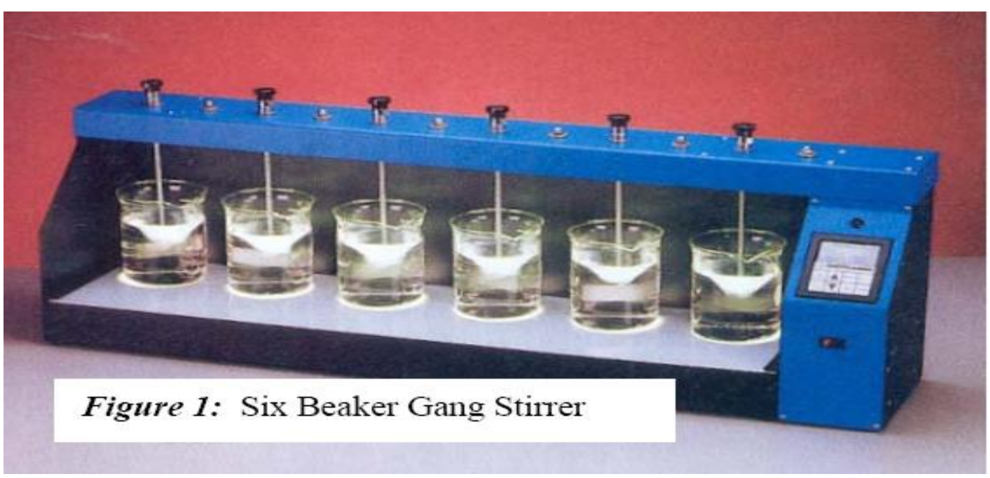


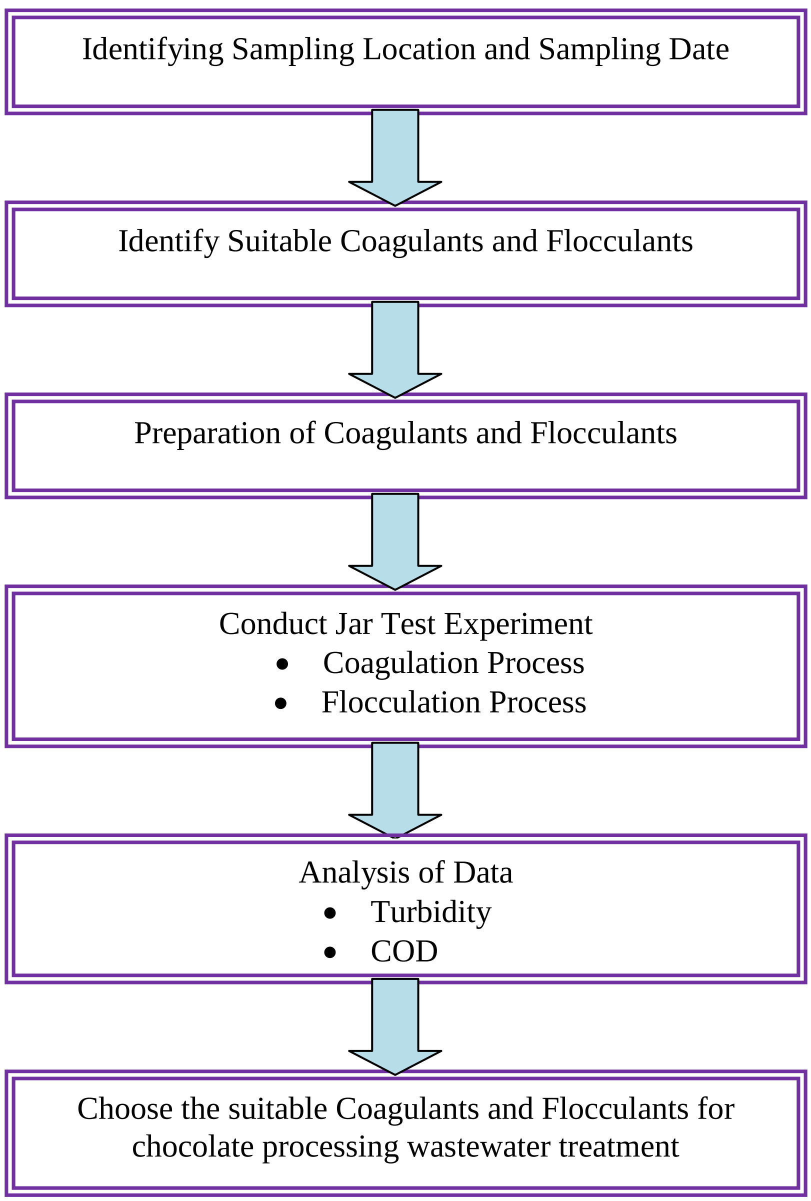
Figure 10: Jar testing experiments

Jar testing entails adjusting the amount of treatment chemicals and the sequence in which they are added to samples of raw water held in jars or beakers. The sample is then stirred so that the formation, development, and settlement of floc can be watched just as it would be in the full scale treatment plant (3). This was performed by mixing one liter of wastewater sample for a short period of rapid mixing (at an impeller rotational speed (*n*) of 100 rpm and mixing time (*t*) of 60 sec) followed by slow mixing (at an impeller rotational speed of 30 rpm and mixing time of 15 min) (Tapas Nandy, 2003).The pH range for effective flocculation can be achieved varies for difference coagulants agents. For ferric salt greater than 4.5 (Tebbutt, 1998), aluminum sulphate between 5.5 and 8.0 (WPCF and ASCE,1977), while polyaluminium chloride is effective over wide pH range above neutral.

CHAPTER 3

METHODOLOGY

3.1 RESEARCH STUDY FLOW CHART

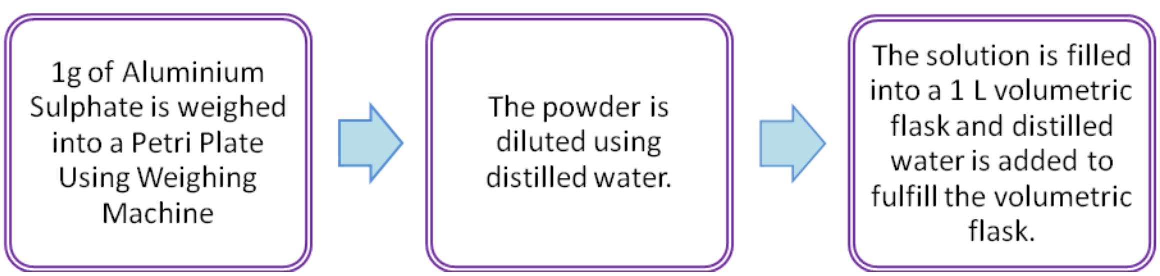


The research finding suitable coagulants and flocculants for chocolate processing wastewater treatment in the flash tank and CAF unit follows key milestone and Gantt chart in the appendix V and VI.

3.2 MATERIAL AND EQUIPMENT

Materials	***Equipments***
Distilled water	Six,1 L beaker
PAC (poly Aluminium chloride)	50 ml Pipet
Aluminium sulfate	Graduated Cylinder
Ferric sulfate	Measuring Cylinder
Ferric Chloride	Turbidimeter
Poly(acrylamide)	Six-place laboratory stirrer
Caustic Soda	pH meter
Sulphuric Acid	

3.3 PREPARATION OF COAGULANTS AND FLOCCULANTS



3.4 METHOD OF EXPERIMENT

3.4.1 Experiment to determine types of chemical for coagulant

1. Decide on three types chemical.
2. Prepare a stock solution of the chemical, 1g/L each.
3. Collect a two gallon sample of the water to be tested. This should be the raw water from chocolate processing industry
4. Measure 500 mL of raw water and place in a beaker. Repeat for the remaining beakers.
5. Analyze the collected natural surface water for pH, turbidity, and alkalinity.
6. Place beakers in the stirring machine.
7. With the stirring paddles lowered into the beakers, start the stirring machine and operate it for one minute at a speed of 200 RPM. Add 50ml of the chemicals to each reactor near the vortex. All the reactors should be dosed at the same time. While the stirrer operates, record of floc appearance of the water in each beaker.
8. Reduce the stirring speed to 60 RPM and continue stirring for 9 minutes. Observe the reactors at 3 minutes intervals to detect the formation of flocs. Reduce mixing to 30 RPM for 4 minutes. Reduce further to 15 RPM for 2 minutes.
9. Find out the turbidity and COD of each sample.
10. Estimate the depth of sludge in each jar.
11. Plot the turbidity against types of coagulants.
12. Plot COD against types of coagulants.

3.4.2 Experiment to determine chemical dosage for coagulant

1. From the experiment 3.4.1, used the clearest turbidty and highest percentage removal of COD for types of chemical.
2. Decide on six dosages of chemical 2.5,2.0,1.5,0.8,0.5 g/L. Using formula $M_1 V_1 = M_2 V_2$
3. Prepare a stock solution of the chemical.
4. Repeat steps 3-10 from experiment 3.4.1
5. Plot the turbidity against coagulant dosage
6. Plot COD against coagulants dosage
7. Select the optimum dosage from the graph

3.4.3 Experiment to determine rapid mixing for coagulant

1. From the experiment 3.4.2, used the same chemical and optimum dosage.
2. Repeat steps 2-10 from experiment 3.4.1 with increasing rapid mixing at 150 RPM, 180 RPM, 250 RPM, 300 RPM
3. Plot the turbidity against rapid mixing
4. Plot COD against rapid mixing
5. Select the optimum rapid mixing from the graph

3.4.4 Experiment to determine optimum pH for coagulant

1. From the experiment 3.4.3, used the same chemical and optimum dosage.
2. Repeat steps 2-5 from experiment 3.4.1
3. Place beakers in the stirring machine. Prepare each beaker for difference pH using sulphuric acid and caustic soda using measuring pipet. Stirred the solution at optimum rapid mixing. (pH 3,5,7,9,12 and one beaker as a control).

4. With a measuring pipet, add the correct of coagulant solution to each beaker as rapidly as possible.
5. With the stirring paddles lowered into the beakers, start the stirring machine and operate it for one minute at optimum rapid mixing. While the stirrer operates, record the appearance of the water in each beaker. Note the presence or absence of floc, the cloudy or clear appearance of water, and the color of the water and floc.
6. Repeat steps 7-10 from experiment 3.4.1
7. Plot turbidity against pH
8. Plot COD against pH
9. Select the optimum pH from the graph.

3.4.5 Experiment to determine types of chemical for flocculant

1. From the experiment 3.4.4, used the same coagulant at optimum chemical dosage, optimum rapid mixing and optimum pH which have clear turbidity.
2. Prepare a stock solution of the chemical, 1 g/L each.
3. Repeat Experiment 3.4.1, but change it to flocculant.

3.4.6 Experiment to determine chemical dosage for flocculant

1. From the experiment 3.4.5, used the same flocculant which have clear turbidity and highest percentage removal of COD.
2. Prepare a stock solution of the chemical, 1, 1.5, 1.9, 2.5 g/L each. Using formula $M_1 V_1 = M_2 V_2$
3. Repeat Experiment 3.4.2, but change it to flocculant.

3.4.7 Experiment to determine optimum pH for flocculant.

1. From the experiment 3.4.6, used the same flocculant which have clear turbidity at optimum chemical dosage.
2. Repeat experiment 3.4.4, but change it to flocculant.

3.5 ANALYSIS OF EXPERIMENT

3.5.1 Turbidity Analysis

15ml of sample was taken from coagulation/flocculation process

The sample is put into the vial and capped closed

Capped vial is been put into turbidity meter

3 readings are taken from each sample and been recorded

3.5.2 COD Analysis

2ml of sample was taken from coagulation /flocculation process

The sample was been put inside the sample kit

The sample kit was been put in the COD reactor for 2 hours

3 readings were been taken from each sample and been recorded

CHAPTER 4
RESULTS AND DISCUSSIONS

4.1 OVERVIEW

As for this chapter, analysis of result will be discussed further. Some results for the parameter tested (coagulant dose, pH and speed & duration of rapid & slow mixing) will be explained. Sample of chocolate processing of wastewater is taken from Cadbury Confectionery (M) Sdn Bhd and the sample is taken from the equalization tank.

The experiment is divided into 2 parts. For the first part, the experiments are conducted to test coagulation process and followed by flocculation process. Jar test as a conventional method which has been used more than 50 years was applied to optimize the variables including coagulant dose, pH and speed & duration of rapid mixing (Zamorano *et al.*,2004). In the first parts, aluminum sulphate, ferric chloride and ferric sulfate were examined. Following the same experiment for flocculation process, poly aluminum chloride and poly acryl amide were examined.

4.2 COAGULANTION PROCESS

4.2.1 Coagulants Test

This test is done to take the best coagulants for the coagulation process. From the three coagulants tested, which is aluminium sulphate, ferric chloride and ferric sulfate, It can be observed that best coagulant is aluminium sulphate which is different as compared to others. The experimental data revealed 70.8% COD removal compared to 63.3% ferric chloride and

63.5% ferric sulfate. While for the turbidity test revealed, that aluminium sulphate has the lowest turbidity value 432 NTU which is clearest than other coagulants 542 NTU ferric chloride and 539 NTU ferric sulfate from incoming wastewater which is 20,000 NTU. Hence, from this result aluminium sulphate is being chosen for coagulants in coagulation process.

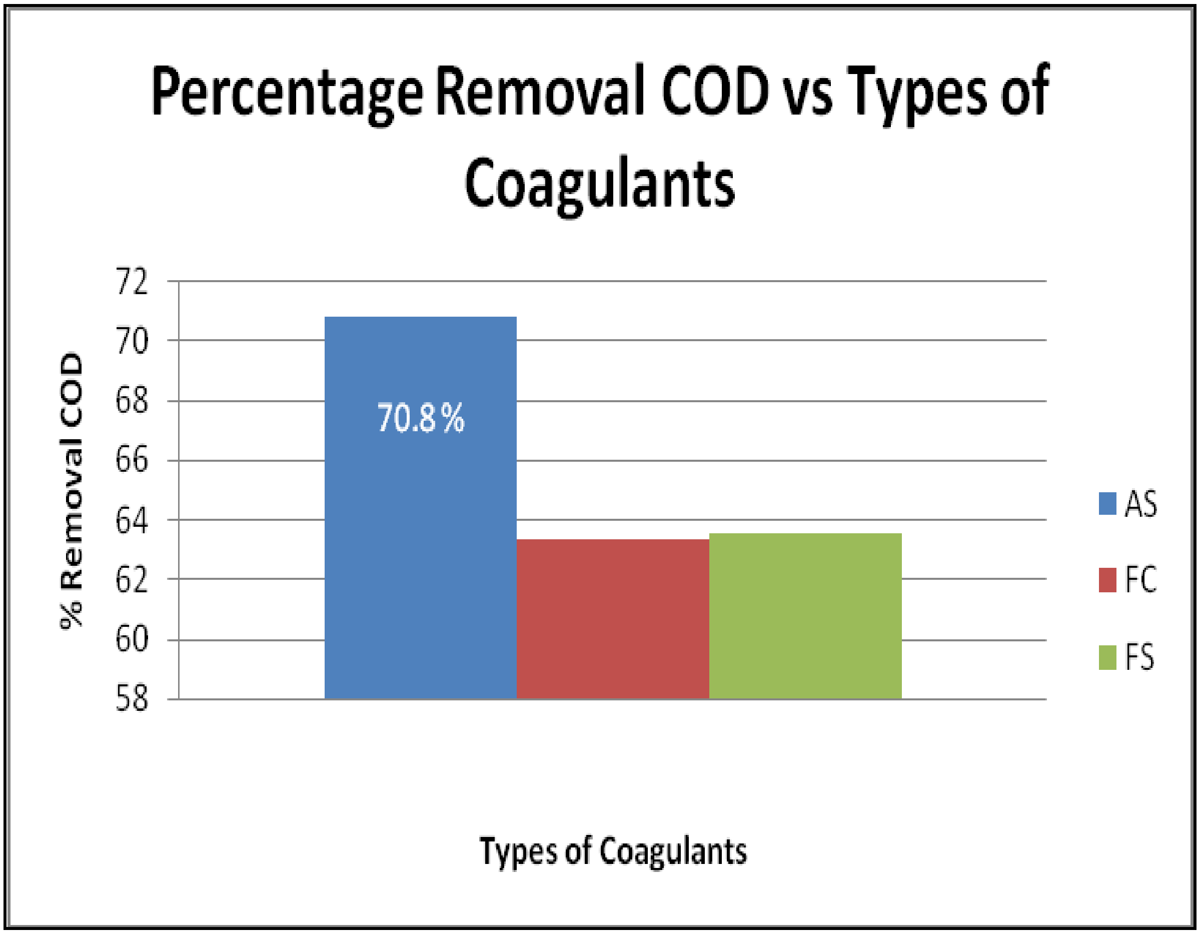


Figure 11: Graph of percentage COD removal for types of coagulants

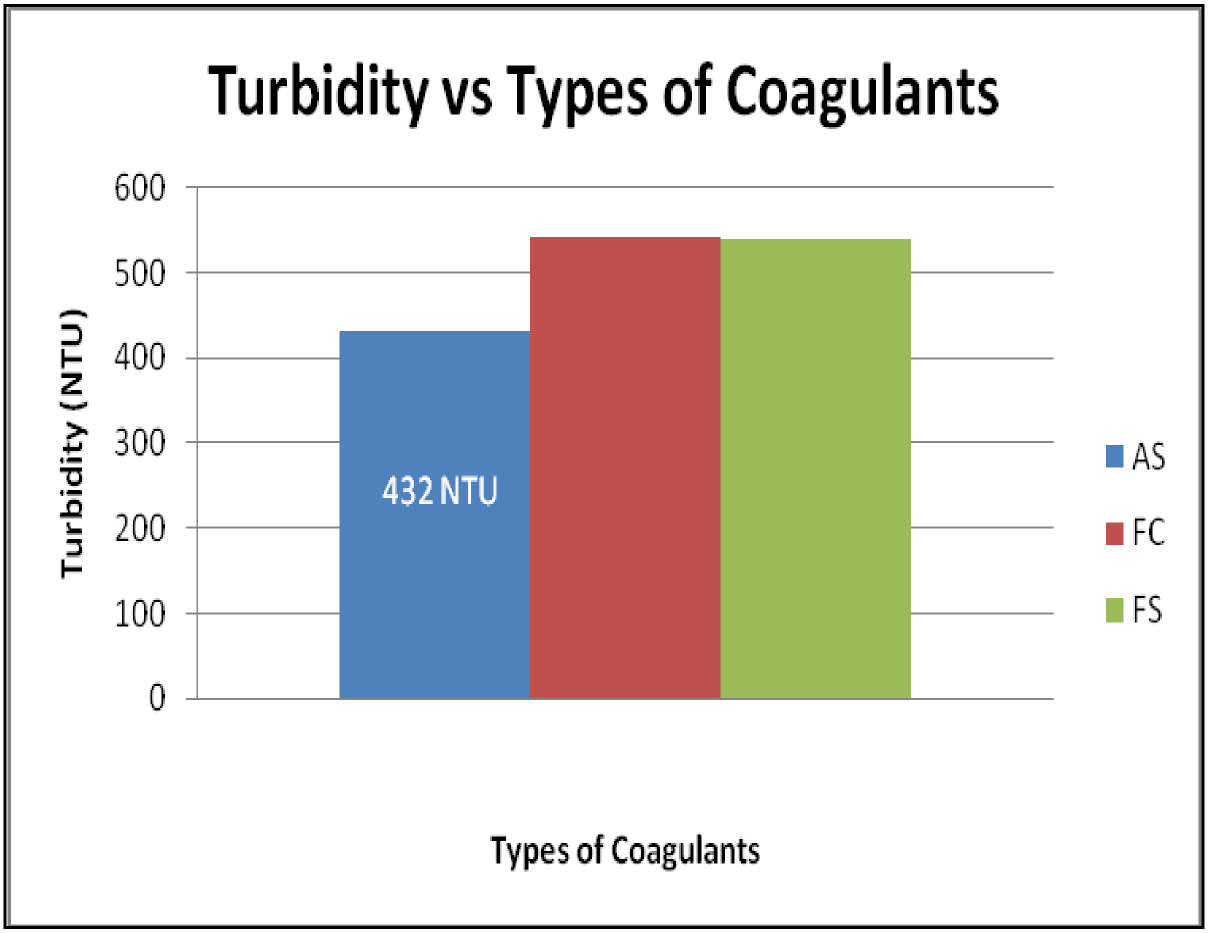


Figure 12: Turbidity for types of coagulants

4.2.2 Optimal Coagulants Dosage Test

The test is continued to examine optimal coagulants dose for Aluminium Sulphate. Several coagulants doses were tested in the range 0.5 to 2.5 g/l at neutral pH. The results of experiments are presented in figures below. It can be observed that the optimal coagulant dose (OpCD) of Aluminium Sulphate was 1.5 g/L with percentage removal of COD 78.2% and turbidity 322 NTU. From the result, we can obtain that if we increased or decreased coagulant dose, it could not treat effluent efficiently. Thus, this will save company budget from flowing out.

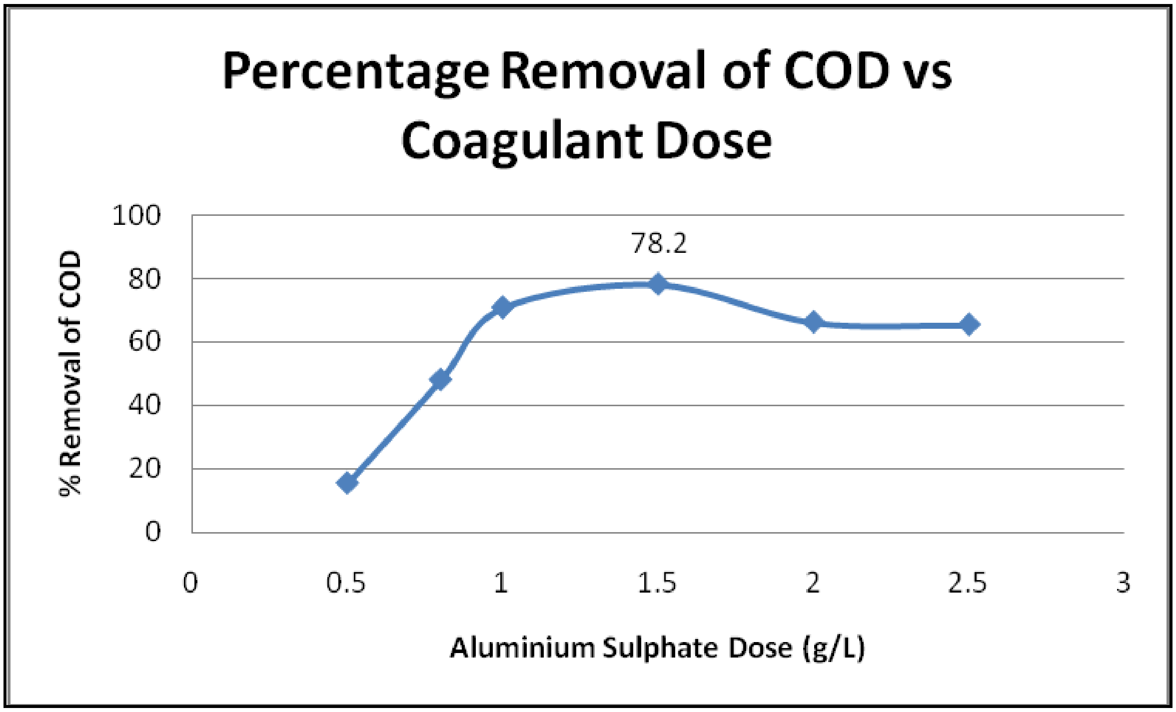


Figure 13 : Percentage Removal of COD for Coagulants Dosage

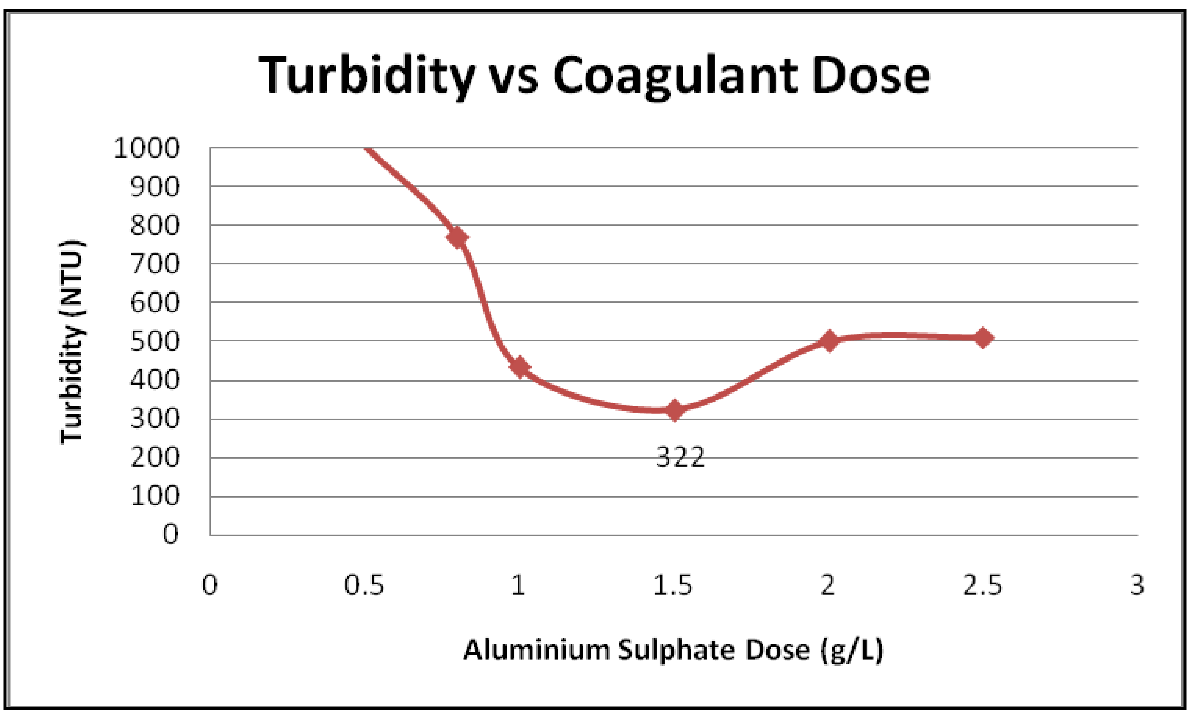


Figure 14: Turbidity for Coagulant Dosage

4.2.3 Optimal Rapid Mixing Test

To investigate the proper speed of rapid mixing, several experiments were performed in the wide speed range of 150 to 300 rpm at 30 minutes. OpCD was applied during experiments in different speeds were tested. Figures below show the investigation of the effect of different speeds (150, 180, 200, 250 and 300 rpm) during 30 minutes. Consequently, the best removal observed in speed 200 and 250 rpm for Aluminium Sulphate with percentage removal of COD is 78.2 % and 320 NTU.

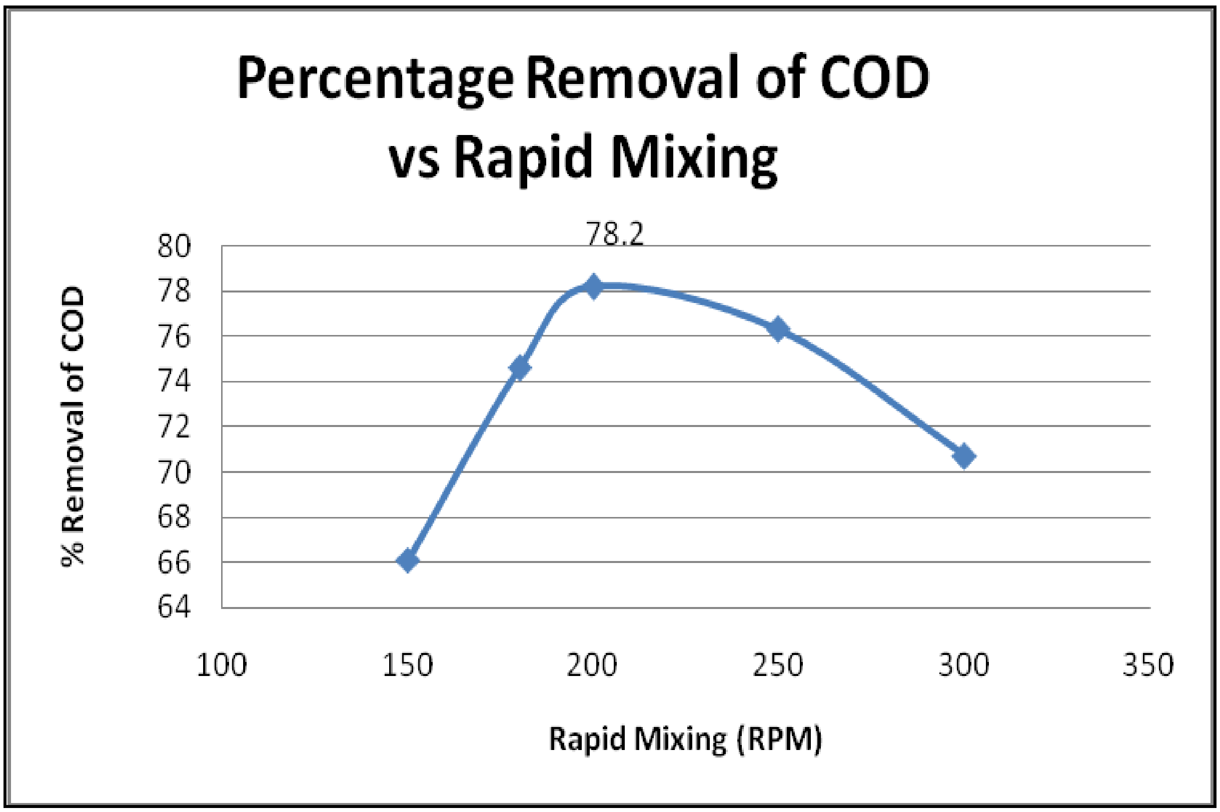


Figure 15: Percentage Removal of COD for Rapid Mixing

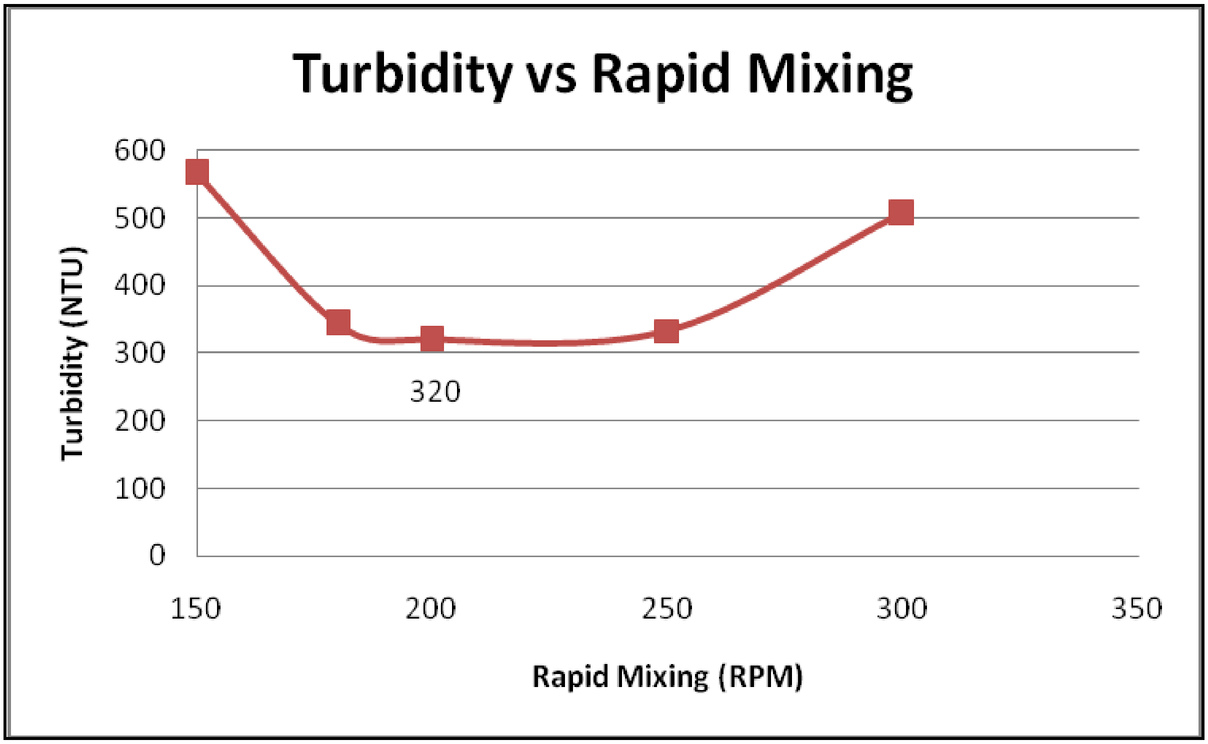


Figure 16: Turbidity for Rapid Mixing

4.2.4 Optimal pH Test

To investigate the best pH, in which the best percent reduction of effluent characteristics occurred, different pH values were tested whereas optimum coagulant dose and rapid mixing were applied to perform coagulation process. The range of examined pH between 3 to 12 while the original pH value of raw water was 4.6. Sulfuric acid (H_2SO_4, 1M) and sodium hydroxide (NaOH, 1M) were used for pH adjustment. Besides, one beaker from optimal coagulant dosage and rapid mixing was taken from previous experiment which pH value was 7.16. According to Figures below, higher efficiency of coagulation with Aluminium Sulphate in pH range of 4.0 to 5.0. According to obtained results the optimum pH was determined 4.6 with percentage removal of COD was 90.9 % with turbidity 228 NTU.

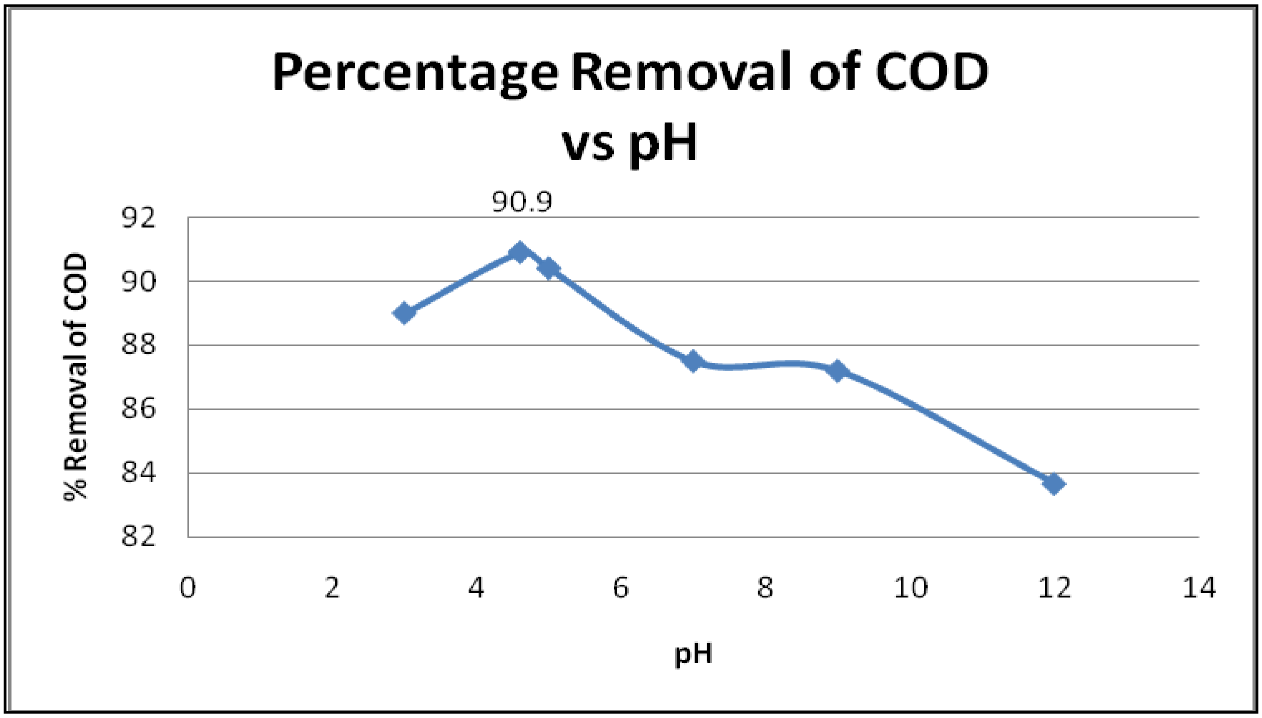


Figure 17 : Percentage Removal of COD for pH

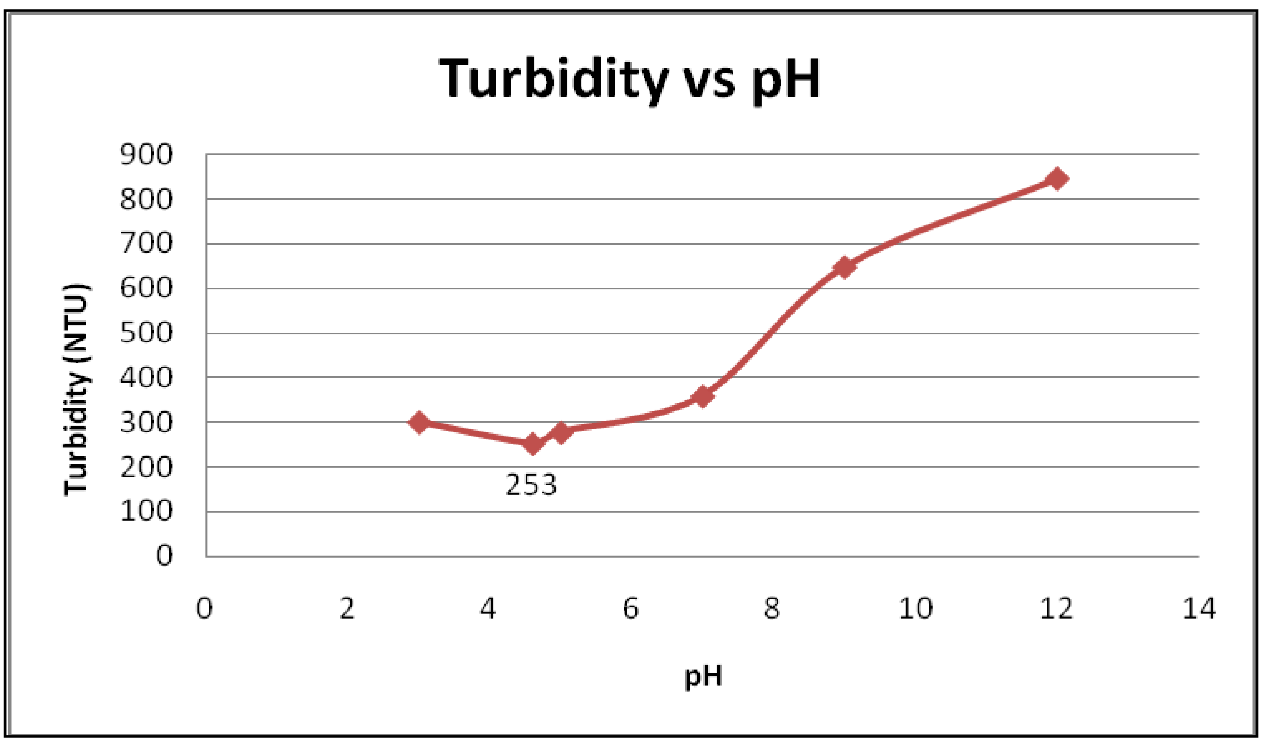


Figure 18: Turbidity for pH

From the experiment, it shown that suitable coagulant is Aluminium Sulphate

1. optimum dosage around 1.5 g/L
2. optimum impeller speed, 200 rpm.
3. optimum pH around 4.6

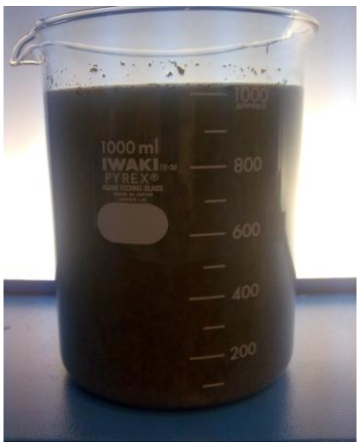


Figure 19: Before Coagulation Process

Figure 20: After Coagulation Process

4.3 FLOCCULATION PROCESS

4.3.1 Flocculants Test

This test is done to take the best flocculants for the flocculation process. The process is continuos from coagulation process using Aluminum Sulphate with dosage 1.5 g/L, pH around 4.5 and rapid mixing at 200RPM. From the two flocculants tested, which is Poly Aluminium Chloride (PAC) and Poly Acryl Amide (PAM). It can be observed that best flocculant is PAC which is different as compared to PAM. The experimental data revealed 94.3% COD removal compared to 87.7% PAM. While for the turbidity test revealed, that PAC has low turbidity value 84 NTU which is clearer than PAM 252 NTU. Hence, from this result PAC is being chosen for flocculants in flocculation process.

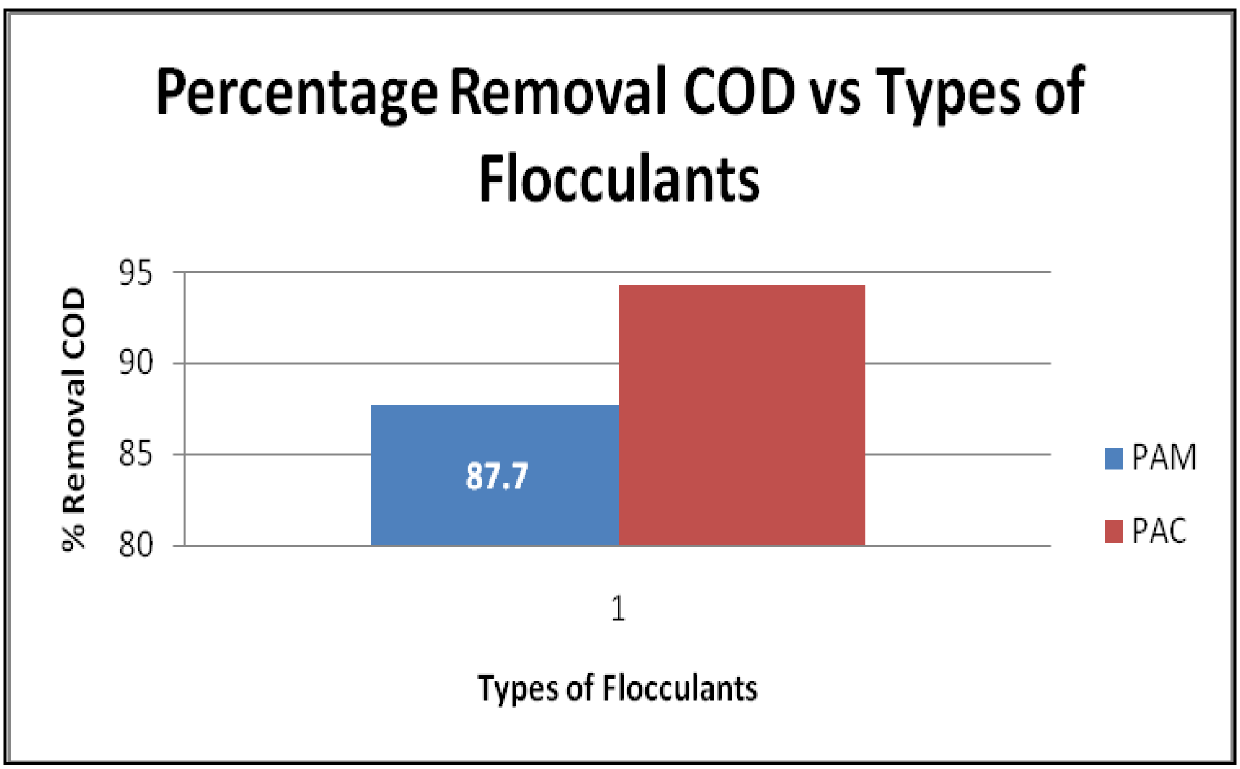


Figure 21: Graph of percentage COD removal for types of flocculants

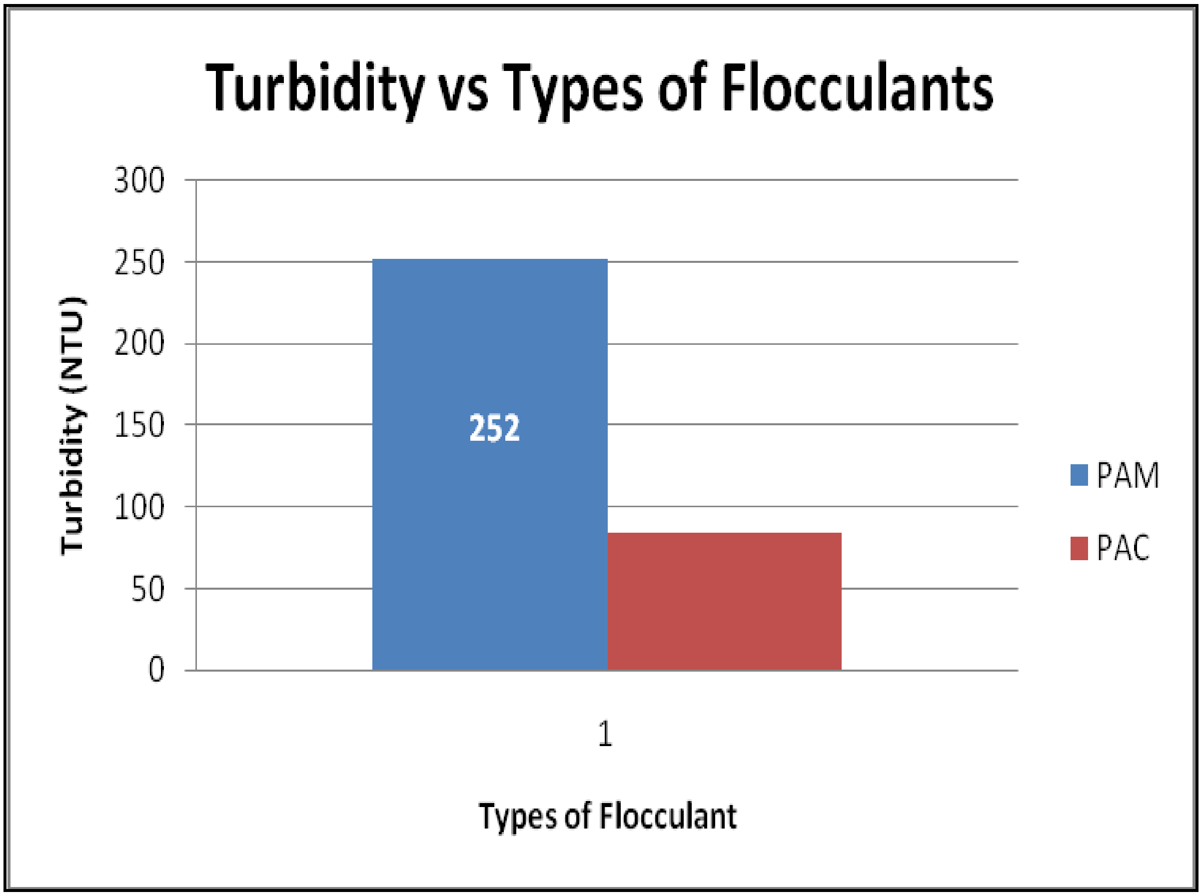


Figure 22 : Turbidity for types of flocculants

4.3.2 Optimal Flocculants Dosage Test

The test is continued to examine optimal flocculants dose for PAC. Several flocculants doses were tested at neutral pH. The results of experiments are presented in figures below. It can be observed that the optimal flocculant dose (OpFD) of PAC chloride was 1.9 g/L with percentage removal of COD 94.3% and turbidity 84 NTU. From the result, effluent will be treated efficiently with optimal flocculant dosage. If the amount of flocculant dose in the CAF unit is less or more than the optimal dosage it can effect the separation process. Thus, the operator must make sure only optimal flocculant dose in the CAF unit.

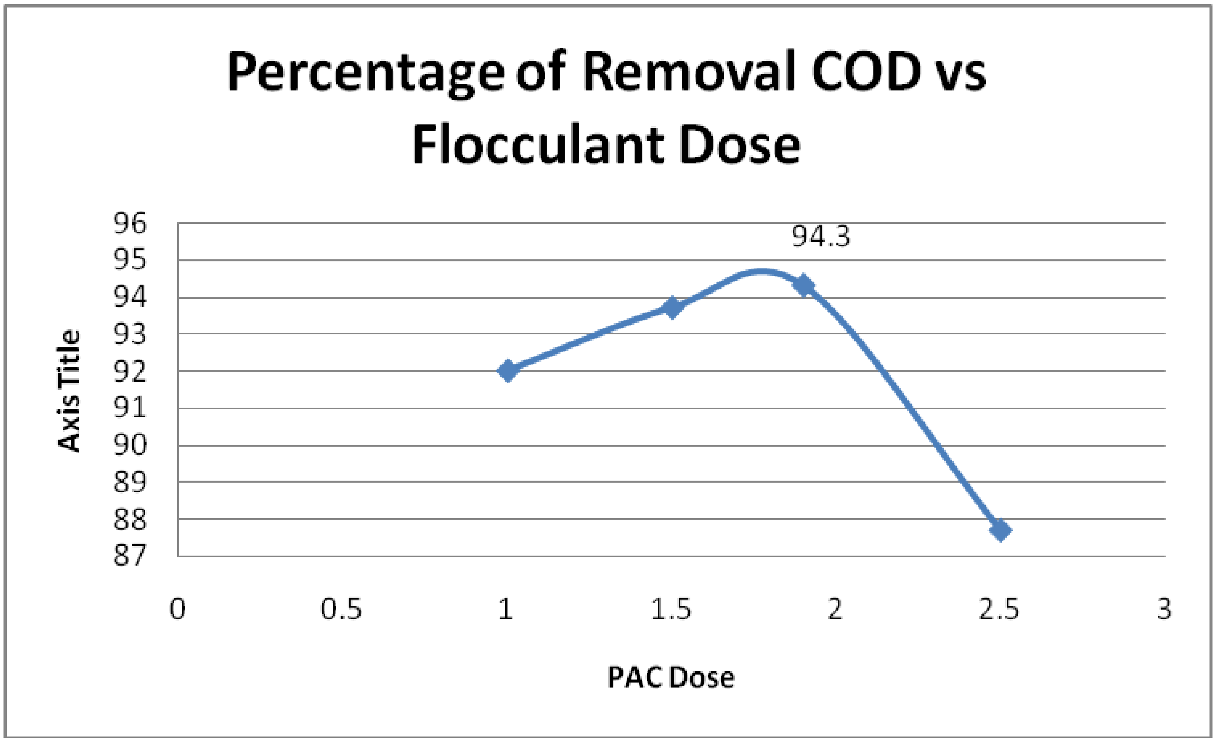


Figure 23 : Percentage Removal of COD for Flocculants Dosage

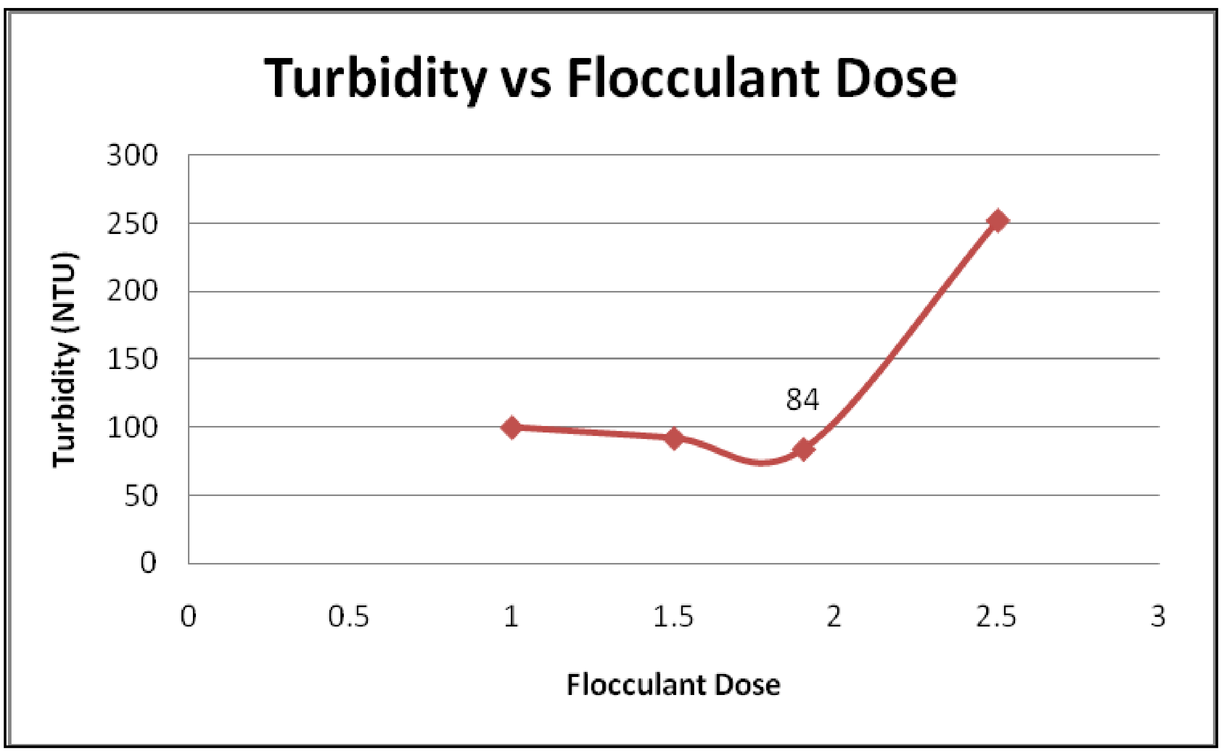


Figure 24: Turbidity for Flocculant Dosage

4.3.3 Optimal pH Test

To investigate the best pH, in which the best percent reduction of effluent characteristics occurred, different pH values were tested whereas optimum flocculant dose to perform flocculation process. The range of examined pH between 3 to 12 while the original pH value from coagulation process which is inside flash tank pH 4.6. Sulfuric acid (H_2SO_4, 1M) and sodium hydroxide (NaOH, 1M) were used for pH adjustment. Besides, one beaker from optimal flocculant dosage was taken from previous experiment which pH value was 6.17. According to Figures below, higher efficiency of flocculation process with PAC in pH range of 6 to 7. According to obtained results the optimum pH was determined 7 with percentage removal of COD was 96.7 % with turbidity 12 NTU.

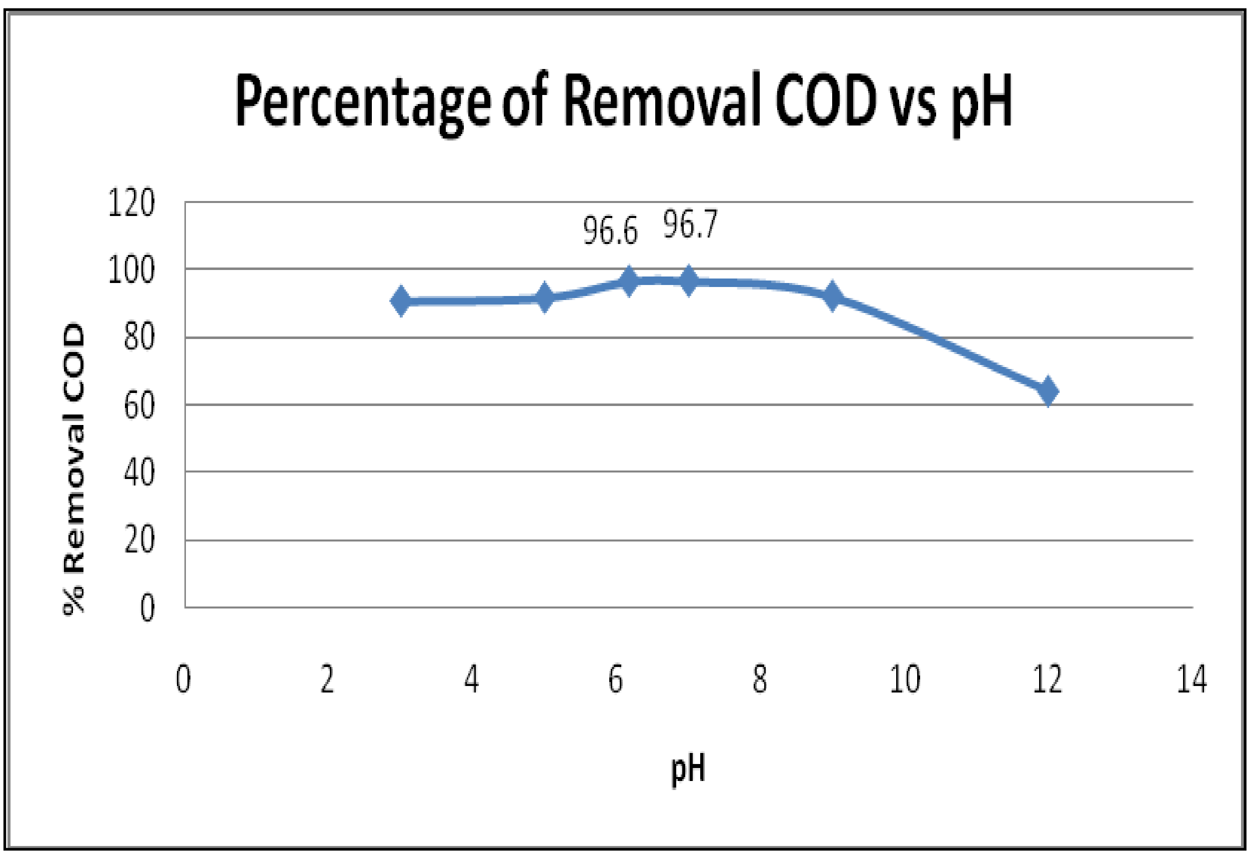


Figure 25: Percentage Removal of COD for pH

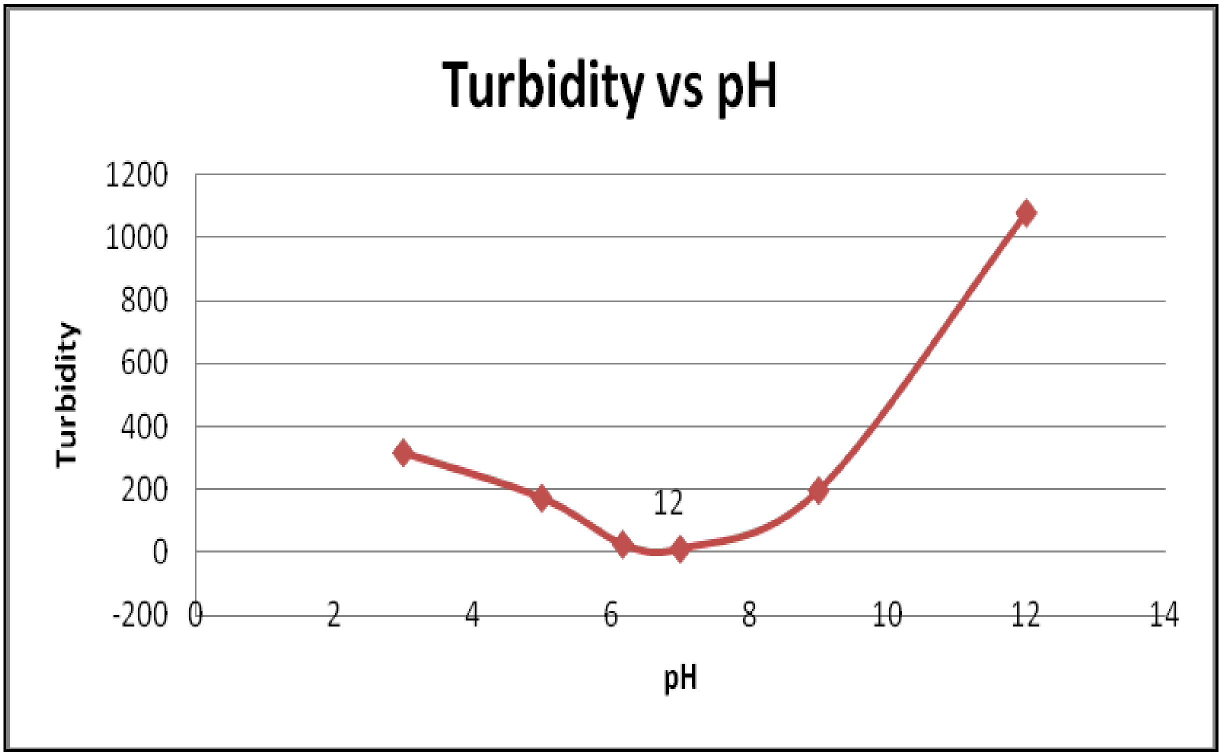


Figure 26: Turbidity for pH

From the experiment, it shown that suitable flocculant is Poly Aluminium Chloride (PAC)

1. optimum dosage around 1.9 g/L
2. optimum pH around 6 to 7

Figure 27: Before Flocculation Process

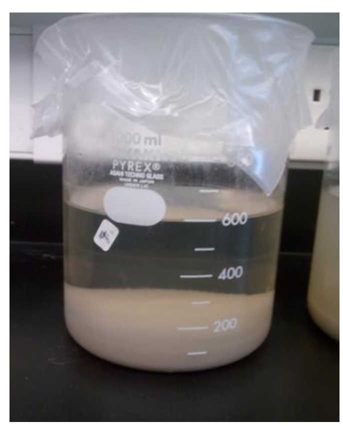


Figure 28: After Flocculation Process

CHAPTER 5

CONCLUSION AND RECOMMENDATION

5.1 RELEVANCY OF OBJECTIVES

In conclusions, methods finding suitable coagulants and flocculants have been identified. Four parameters are applied to find most suitable coagulants and flocculants for chocolate processing wastewater treatment in the flash tank and CAF unit. The methods are to conduct experiment starting with finding types of chemical for coagulants, followed by chemical dosage and after that rapid mixing and optimum pH. After that, substitute coagulants with flocculants. Based on detailed experimentation on coagulation-flocculation process, this mode of treatment has proved to be an appropriate pre-treatment option for chocolate processing wastewater treatment. Moreover, suspended solids removal is also very high with stable performance achieved for removal of organic substances in terms of COD and turbidity. Among the coagulants experimented, Aluminium Sulphate performed as the most efficient coagulation in the flash tank. Use of Poly Aluminium Chloride for flocculation to improved the treatment efficiency resulting increased floc separation through in CAF unit. 96.7% removal of COD and 99.9 % reduction of turbidity from raw water were achieved by using the Aluminium Sulphate and Poly Aluminium Chloride, in the optimum dosage, PH range and rapid mixing. Meanwhile, further research and development would be continuously practiced to ensure satisfactory results are achieved.

5.2 FUTURE WORK.

Below are the suggested plan future work for the expansion and continuation of this research study;

i. Separate settling sludge after coagulation process before sent to flocculation process
ii. Preparation of other coagulants and flocculants.
iii. Research on BOD and TOC of chocolate processing wastewater.
iv. Running the experiment according to the experiment matrix.

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APPENDICES

Appendix 1 : LOCAL REGULATIONS

Appendix 2 : MSDS COAGULANTS

Appendix 3 : MSDS FLOCCULANTS

Appendix 4 : KEY MILESTONE

Appendix 5 : GANTT CHART